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1976 Edition



U.S. DEPARTMENT OF COMMERCE · National Bureau of Standards

Attacking the Fire Problem: A Plan for ACTION



Center for Fire Research

NATIONAL BUREAU OF STANDARDS

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[1] Headquarters and Laboratories at Gaithersburg, Maryland, unless otherwise noted; mailing address Washington, D.C. 20234.
[2] Part of the Center for Radiation Research.
[3] Located at Boulder, Colorado 80302.
[4] Part of the Center for Building Technology.

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Office of Standard Reference Data — Office of Information Activities — Office of Technical Publications — Library — Office of International Relations.

Attacking the Fire Problem: A Plan for Action—1976 Edition

F. B. Clarke, and D. W. Raisher, Editors

Center for Fire Research
Institute for Applied Technology
National Bureau of Standards
Washington, D.C. 20234



U.S. DEPARTMENT OF COMMERCE, Rogers C. B. Morton, *Secretary*

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PREFACE

On October 29, 1974, President Ford signed into law the Federal Fire Prevention and Control Act of 1974. This legislation is the direct result of the findings of the President's Commission on Fire Prevention and Control, and it reflects the Commission's findings that America's fire losses are disgraceful and totally unacceptable to a country whose level of technology and human resources is the highest in the world.

The Congress intended the Federal Fire Prevention and Control Act of 1974 to provide new impetus to solving the Nation's fire problem. In addition to creating the National Fire Prevention and Control Administration within the Department of Commerce, the Act provides for the establishment of a separate Fire Research Center (CFR) at the National Bureau of Standards. The Fire Research Center is charged with understanding fundamental processes of fire, including its physics and chemistry; its behavior, spread and growth in buildings; the fire hazards uniquely arising from transportation of combustible fluids and materials; and design concepts for increased fire safety in the built environment. Further, the Congress authorized the Fire Research Center to carry out investigations into the biological, physiological, and psychological factors affecting the victims of fire. In particular, the biological and physiological effects of toxic substances on fire victims, and the psychological and motivational characteristics induced either by fire stress or fire trauma are to be systematically studied for the first time.

Thus, the Congress has created within the National Bureau of Standards a Fire Research Center with a broad mandate for understanding fire and its myriad effects, and for reducing the unconscionable losses which attend it.

Attacking the Fire Problem
A Plan for Action

FIRE SCIENCE

Information & Hazard Analysis | Chemistry | Toxicology of Combustion Products | Physics & Dynamics

FIRE SAFETY ENGINEERING

Fire Prevention • Products | Fire Control • Furnishings | Fire Control • Construction | Fire Detection & Control Systems | Design Concepts

Goals

Tools to Reduce Fire Losses by 50%

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Abstract

The mission of the Center for Fire Research is to insure the development of the technical base for the standards and specifications needed in support of the National goal to reduce fire losses by 50% over the next generation. A systems approach to accomplish this mission is described. The Center consists of four basic programs in the area of Fire Science and five applied research programs in the area of Fire Safety Engineering. Each applied program addresses an aspect of the Fire Problem, using fundamental information supplied by the basic research function. Active participation by staff members in voluntary standards organizations is the principal means of making this technology available for codes and standards needed to reduce the Nation's fire loss.

Key words: Building design; consumer protection; fire control; fire detection; fire research; fire spread; flammability.

Center for
Fire
Research

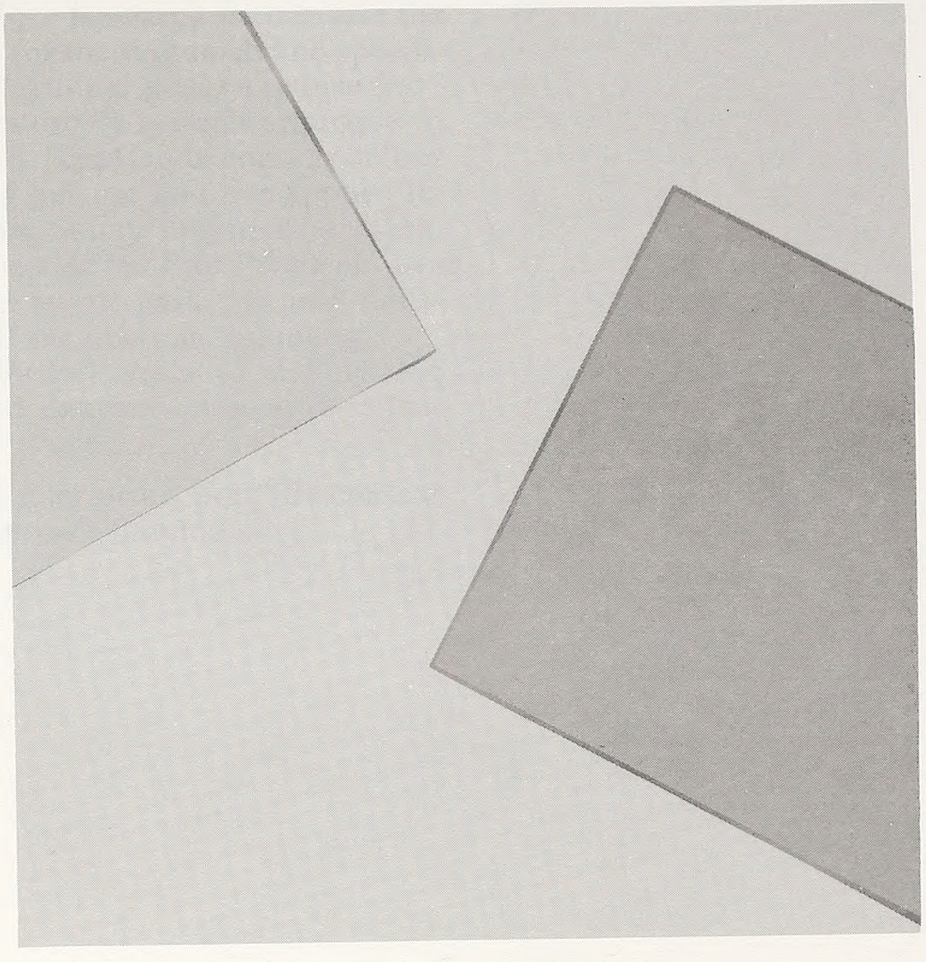


ATTACKING THE FIRE PROBLEM

The goal of the
Center for Fire Research
is to insure the development
of the technical base for the
standards and specifications
needed in support of the
National goal to reduce
fire losses by 50%
over the next
generation.

CONFRONTATION:

Attacking the Fire Problem



Unwanted fire reaps a grim toll in the United States. Each year more than twelve thousand of our citizens die in fires and several hundred thousand more suffer serious burn injuries. In addition to this human suffering, property damage drains some eleven billion dollars from our economy. These figures, stark in themselves, are all the more shocking when they are contrasted with figures from other industrialized countries. For example, Japan reports 0.61 fires for each thousand persons as compared to 13.0 for the United States. Japan has 14.2 fire deaths for each million persons vs. 57.1 in the United States. Figures can be recited for several European countries to the same effect. While the statistical basis for these figures is less than perfect, the unfavorable position of the United States seems beyond dispute.

No one knows why our Nation's losses are so great, although some of the very characteristics which make the United States unique may also contribute to the problem. For example, our homes are generally of wood construction, as compared to the stone and concrete commonly used in Western Europe, and they are replete with plush furnishings. Further, there is some correlation between energy consumption and fire incidence. An important social factor is the attitudes people have: in the United States we view fire as a misfortune or an unavoidable accident, while Japan deals with the fact of having a fire as a felony.

Despite the fact that unwanted fires are complex phenomena with cause and effect poorly understood, simplistic solutions abound. Some call for intense public education as the only answer, on the assumption that most fires are caused by people. Others believe that using such devices as automatic sprinklers in all occupancies will solve the Fire Problem. Yet, both of these approaches have their limitations. For example, much of human behavior, especially that of infants, the very old, and the mentally handicapped, is uncontrollable. The victims of this behavior may be other innocent persons, perhaps asleep in neighboring rooms. We must deal with the problem on the assumption that people will, on occasion, be careless and that accidents will happen. Yet, life safety is often endangered well before a fire reaches the detectable threshold for sprinkler systems, however reliable they may be. Therefore, it should be clear that a single remedy for the entire scope of the Fire Problem does not exist or, if it does, it will only be uncovered by further research.

The National Bureau of Standards has been the Nation's fire research laboratory for over five decades;[1] our laboratory facilities for fire research are excellent. The staff cooperates closely with individuals and groups at home and abroad who are working to decrease fire losses. The National Fire Prevention and Control Administration, the fire services, the Congress, various universities, the National Fire Protection Association, building code officials and voluntary standards organizations share with us the challenge to make our environment safer from the ravages of fire.

We are just now gaining a measure of quantitative understanding of fire phenomena. Fire technology is moving slowly from childhood to adolescence, but it is a long way from being a mature science. Nevertheless, action on fire cannot wait for a total understanding of the appropriate physical and chemical phenomena.[2,3] The world demands, now, criteria and recommended practices for controlling fire hazards. In short, an attack on the problem is needed!

Only a balanced approach will provide interim solutions that are both technically sound and immediately applicable. Fire science--its chemistry and physics--and statistical analysis of fire incidence serve as inputs and guides. Fire safety engineering transforms these inputs into the tools the Nation needs to reduce fire loss. The National Bureau of Standards (NBS) directs the results of all these activities to the agencies and organizations with authority to set standards and specifications.

[1]America's Not for Burning, DIMENSIONS/NBS, Nat. Bur. Stand. (U.S.), Vol. 57, No. 11, 264-267 (Nov. 1973), GPO; SD Catalog No. C13.13:57/11; $0.80.

[2]Ibid.

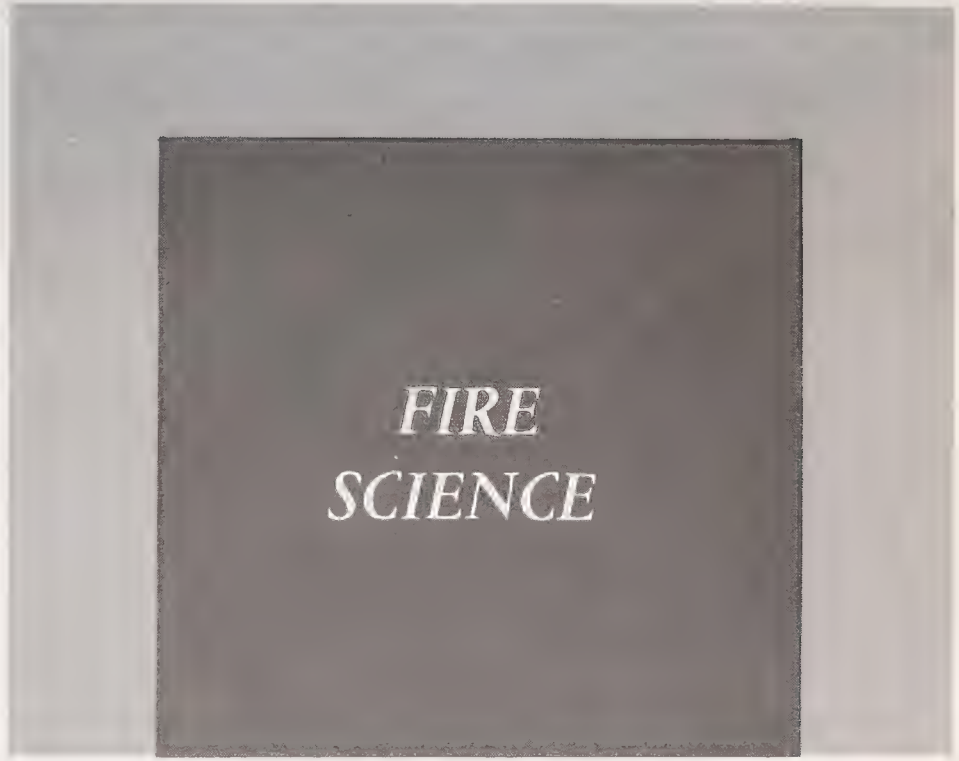
[3]Lyons, J. W., A Look at Fire Research, DIMENSIONS/NBS, Nat. Bur. Stand. (U.S.), Vol. 58, No. 6, 125-126 (June 1974), GPO; SD Catalog No. C13.13:58/6; $0.80.

While the urgency of the Fire Problem cannot be understated, its scope and complexity require that we take a sophisticated systems approach comprised of a balanced attack along a broad front of fire research. The following pages outline that approach and constitute a blueprint for action for the NBS Center for Fire Research.



Attacking the Fire Problem

Center for Fire Research



Accidental fire is the result of complex physical phenomena and human action. The first task in a program for loss reduction is understanding each component of an accidental fire.

One begins by analyzing fire incident data to reveal how fire accidents happen and to spotlight areas which can be impacted by research. This task falls to the Office of Information and Hazard Analysis. Solutions to these problems lie in the fundamental knowledge of fire processes.[4] Broadening our knowledge of flame physics, flame chemistry, and flame retardants is the assignment of the Program for Chemistry, the Program for Toxicology of Combustion Products, and the Program for Physics and Dynamics.

Only when we have an understanding of the physical and human causes of fire incidents can we begin to formulate solutions to the Fire Problem.

[4]Flammability: A New Look at an Age-Old Problem, DIMENSIONS/NBS, Nat. Bur. Stand. (U.S.), Vol. 58, No. 6, 130-131 (June 1974), GPO; SD Catalog No. C13.13:58/6; $0.80.

Office of Information and Hazard Analysis



Objectives: to characterize fire hazards as part of the formulation of fire research goals...to guide test method development for codes and standards...to develop probabilistic models for more quantitative hazard characterization...to provide a central repository for fire research literature and to provide technical information services for the CFR staff and the fire community.

Office of Information and Hazard Analysis

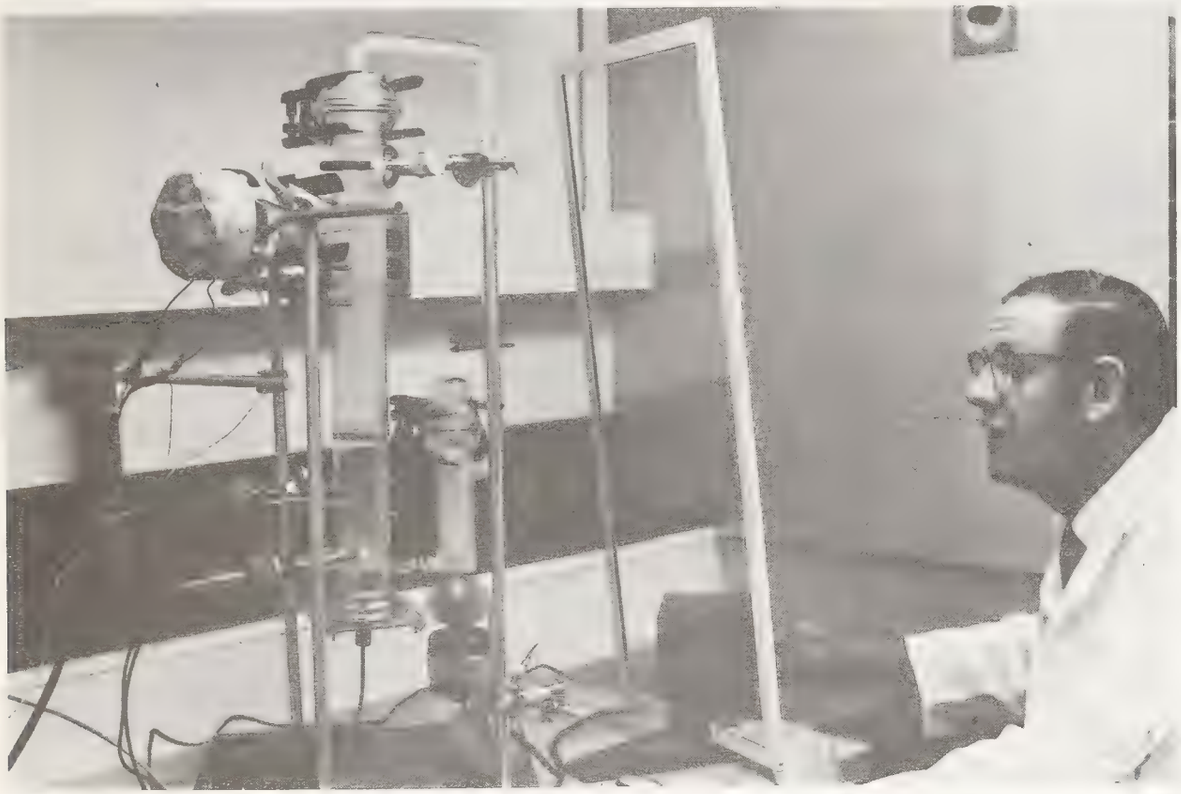
Benjamin Buchbinder, Acting Chief

Current Activities:

- In depth hazard analysis projects in selected problem areas (such as fires involving plastics and apparel) are underway. These projects combine case history investigations of fire accidents, laboratory experimentation, fire testing, and data analysis to identify and characterize specific hazards.
- Studies are being conducted in support of the development of a general apparel flammability standard, including hazard characterization and the recommendation of test methods related to real-world experience.
- A hazard quantification study is in process, encompassing probabilistic model development. Consideration is being given to more quantitative characterization of the fire hazard to compartments and buildings as well as to individual products.
- An analysis of burn injuries from apparel fires is being made, which considers the reactions of victims as well as the composition and shape of the garments.
- A central repository is maintained for fire research literature. Technical information services are provided in support of the fire research program.

Office of Information and Hazard Analysis--Selected Publications:

1. Buchbinder, B., Pilot Implementation of the Fire Incident System, Fire Journal, Vol. 69, No. 3, 65-69 (May 1975).
2. Buchbinder, B. and Mathers, W., Preliminary Indications from Survey of U.S. Household Fire Experience, Proceedings of the Eighth Annual Meeting of the Information Council on Fabric Flammability, Galveston, Texas, 173-178 (1975); held in New York, Dec. 5, 1974.
3. Buchbinder, B. and Vickers, A. K., A Comparison Between Potential Hazard Reduction from Fabric Flammability Standards, Ignition Source Improvement and Public Education. In: Fire Safety Research, Proceedings of a Symposium held at the National Bureau of Standards, Gaithersburg, Md., Aug. 22, 1973. National Bureau of Standards (U.S.), NBS Special Publication 411 (Nov. 1974), GPO; SD Catalog No. C13.10:411; $3.10.
4. Buchbinder, L. B., Human Activity Patterns and Injury Severity in Fire Incidents Involving Apparel, Journal of Fire and Flammability/Consumer Product Flammability, Vol. 1, 4-18 (Mar. 1974).
5. Buchbinder, L. B., Human Behavior Patterns vs. Injury Severity for Apparel Fire Victims, Proceedings of the Seventh Annual Meeting of the Information Council on Fabric Flammability, New York, 4-18 (1974); held in New York, Dec. 5, 1973.
6. Buchbinder, L. B., Relationship of Garment Characteristics and Other Variables to Fire Injury Severity, National Bureau of Standards (U.S.), Tech. Note 867 (June 1975), GPO; SD Catalog No. C13.46:867; $1.25.
7. Jason, N. H., Fire Research Publications, 1973, Final Report, National Bureau of Standards (U.S.), NBSIR 74-511 (June 1974), NTIS Order No. COM 74-11448; $4.00.
8. Jason, N. H., Fire Research Publications, 1974, Final Report, National Bureau of Standards (U.S.), NBSIR 75-736 (June 1975), NTIS Order No. COM 75-11018; $3.25.
9. New Insights on the Causes of Fire Fatalities, DIMENSIONS/NBS, National Bureau of Standards (U.S.), Vol. 59, No. 6, 126-127 (June 1975), GPO; SD Catalog No. C13.13:59/6; $0.80.
10. Tyrrell, E. A., Fire Accidents Involving the Ignition of Sleepwear Worn by Children Under the Age of Three, National Bureau of Standards (U.S.), Tech. Note 815 (Feb. 1974), GPO; SD Catalog No. C13.46:815; $0.60.
11. Tyrrell, E. A., Gasoline and Gasoline Container Fire Incidents, National Bureau of Standards (U.S.), Tech. Note 850 (Jan. 1975), GPO; SD Catalog No. C13.46:850; $0.85.
12. Vickers, A. K., Kitchen Ranges in Fabric Fires, National Bureau of Standards (U.S.), Tech. Note 817 (Apr. 1974), GPO; SD Catalog No. C13.46:817; $0.60.
13. Vickers, A. K., Krasny, J. F., and Tovey, H., Some Apparel Fire Hazard Parameters, Proceedings of the Seventh Annual Meeting of the Information Council on Fabric Flammability, New York, 205-226 (1974); held in New York, Dec. 5, 1973.



Program for Chemistry

Objectives: to provide increased understanding of the chemical processes which are of importance in the development and control of unwanted fires: kinetics and thermodynamics of combustion; pyrolysis; ignition; fire retardation; flame processes; flame inhibition; flame spread; generation of combustible products; and extinguishment.

Program for Chemistry

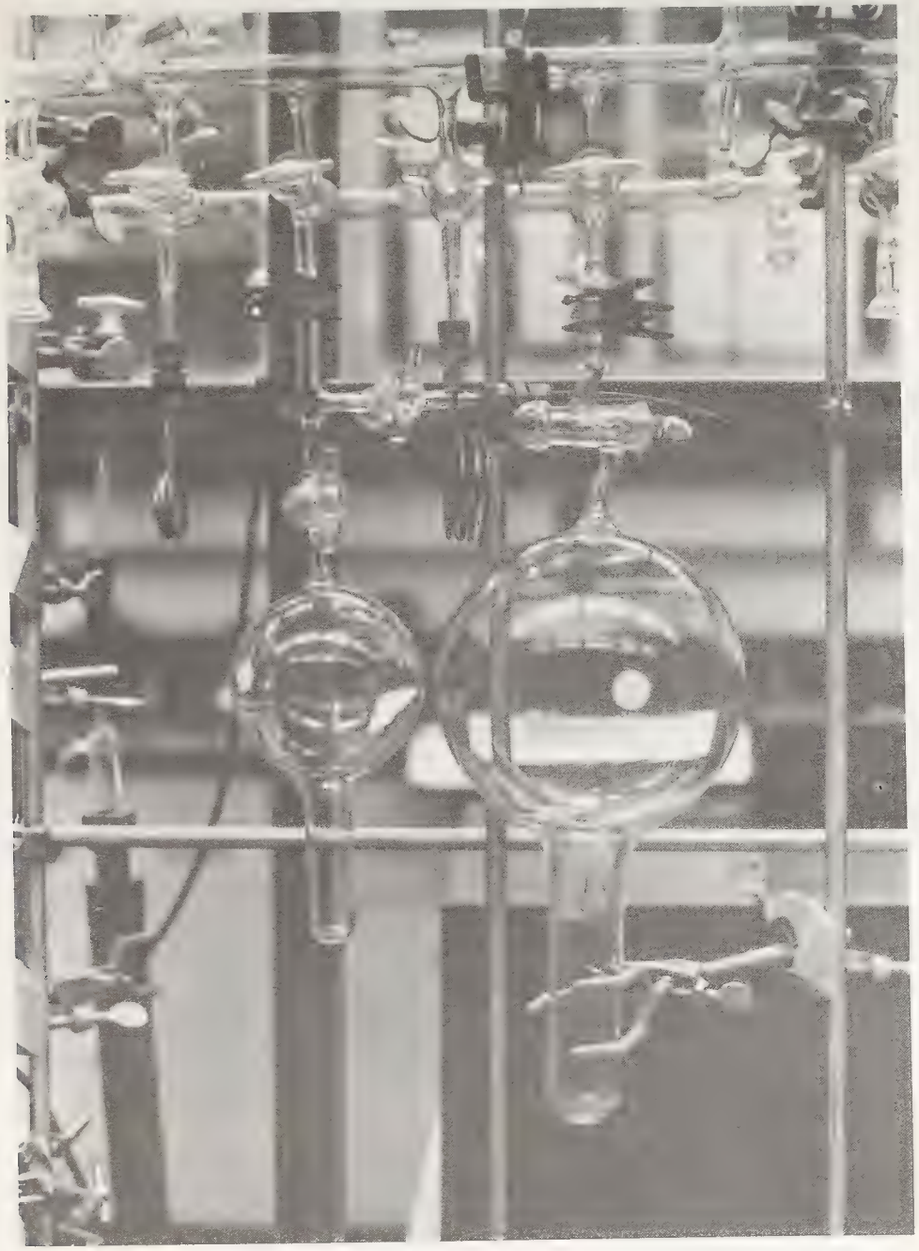
Clayton Huggett, Chief

Current Activities:

- The structure of typical flames, including flames containing chemical retardants, is being studied experimentally by mass spectrometric and optical techniques and theoretically through thermodynamic and kinetic calculations.
- Research grants study chemical kinetics and flame dynamics and develop models of flames and flame inhibition.
- The chemistry and methods of controlling cellulosic fires are being studied for CFR at the University of Montana.
- Clemson University is studying flame retardation mechanisms in fabrics with partial support of CFR.
- With CFR support, the University of Maryland is investigating hydroxyl radical reactions of fundamental importance to flame initiation and propagation.
- Thermodynamic quantities associated with the pyrolysis and stepwise combustion of polymers are being measured experimentally.
- The significance of the oxygen index as a measure of flammability is under investigation.
- The relationship between flammability limits in premixed flames and the oxygen index in diffusion flames is being explored.
- Conditions which can lead to flash fires in compartments are being defined. A method to evaluate the flash fire potential of solid fuels is under development.
- Laser-optical methods are being developed which will detect the presence of high-energy, short-lived intermediates present in flames.

Chemistry--Selected Publications:

1. Birky, M. M. and Yeh, Kwan-nan, Calorimetric Study of Flammable Fabrics, Part I, Instrumentation and Measurements, Journal of Applied Polymer Science, Vol. 17, No. 1, 239-253 (Jan. 1973).
2. Galant, S. and Appleton, J. P., Theoretical Investigation of Inhibition Phenomena in Halogenated Flames. In: Halogenated Fire Suppressants, edited by Richard G. Gann, American Chemical Society Symposia Series No. 16 in the Industrial and Engineering Chemistry State-of-the-Art Series (1975); meeting held in San Antonio, Texas, April 1975.
3. Hastie, J. W., Mass Spectrometric Studies of Flame Inhibition: Analysis of Antimony Trihalides in Flames, Combustion and Flame, Vol. 21, No. 1, 49-54 (Aug. 1973).
4. Hastie, J. W., Molecular Basis of Flame Inhibition, National Bureau of Standards (U.S.), Journal of Research, Vol. 17A, No. 6, 733-754 (Nov.-Dec. 1973).
5. Hastie, J. W. and McBee, C. L., Mechanistic Studies of Halogenated Fire Retardants. In: Halogenated Fire Suppressants, edited by Richard G. Gann, American Chemical Society Symposia Series No. 16 in the Industrial and Engineering Chemistry State-of-the-Art Series (1975); meeting held in San Antonio, Texas, April 1975.
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7. Huggett, C., Habitable Atmospheres Which Do Not Support Combustion, Combustion and Flame, Vol. 20, No. 1, 140-142 (Feb. 1973).
8. Markstein, G. H. and de Ris, J., Flame Spread Along Fuel Edges, Journal of Fire and Flammability, Vol. 6, No. 2, 140-154 (Apr. 1975).
9. Markstein, G. H. and de Ris, J., Upward Fire Spread Over Textiles, Proceedings of the Fourteenth Symposium (International) on Combustion, The Combustion Institute, Pittsburgh, Pa., 1085-1097 (1973); held in State College, Pa., Aug. 1972.
10. Paabo, M. and Comeford, J. J., A Study of the Decomposition Products of Polyurethane Foam Related to Aircraft Cabin Flash Fires, Final Report (July 1973), FA67NF-AP-21, NTIS Order No. AD76-3327; $3.75.
11. Yeh, Kwan-nan, Birky, M. M., and Huggett, C., Calorimetric Study of Flammable Fabrics, Part 2, Analysis of Flame Retardant Treated Cotton, Journal of Applied Polymer Science, Vol. 17, No. 1, 255-268 (Jan. 1973).



Program for Toxicology of Combustion Products

Objectives: to define the smoke and toxicity hazards due to combustion products and to recommend practical methods for their measurement and control.

Program for Toxicology of Combustion Products

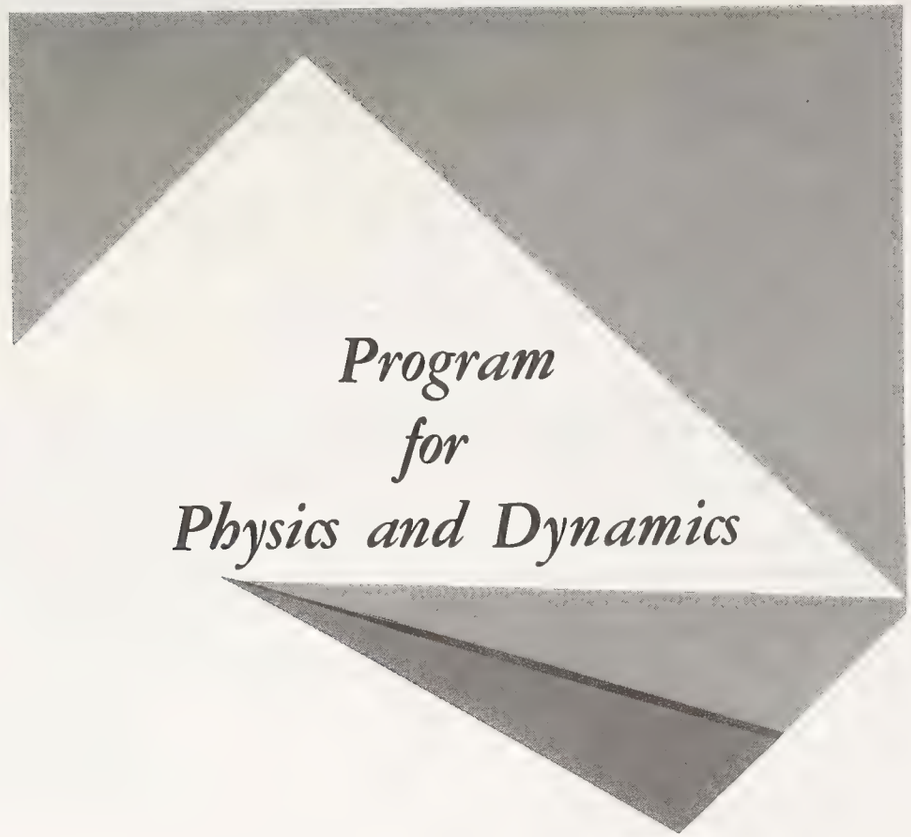
Merritt Birky, Acting Chief

Current Activities

- Major components in combustion samples are quantitatively determined using gas chromatographic, infrared spectroscopic, and wet chemical techniques.
- Analytical measurements of specific toxicants are being correlated with animal behavior and blood chemistry to determine toxicity hazard.
- Correlation of laboratory and full-scale smoke and gas measurements will be made.
- Under CFR grants, the University of Pittsburgh and the University of Utah are conducting biomedical studies to assess the toxicity of combustion products from a variety of materials using laboratory-scale experiments.
- CFR is supporting work at the Applied Physics Laboratory of Johns Hopkins University which is working with the Maryland State Medical Examiner's Office to determine the causes of deaths in fires in the State of Maryland.

Toxicology of Combustion Products--Selected Publications:

1. Birky, M. M., Einhorn, I. N., Seader, J. D., Kanakia, M. D., and Chien, W. P., The Effects of Fire Retardants on the Combustion of Rigid-Urethane Foams, Journal of Fire and Flammability/Fire Retardant Chemistry, Vol. 1, 35-55 (Feb. 1974).
2. Chien, W. P., Seader, J. D., and Birky, M. M., Monitoring Weight Loss in an NBS Smoke Chamber, Fire Technology, Vol. 9, No. 4, 285-298 (Nov. 1973).
3. Comeford, J. J. and Birky, M. M., A Method for the Measurement of Smoke and HCl Evolution from Poly(vinyl chloride), Fire Technology, Vol. 8, No. 2, 85-90 (May 1972).
4. Halpin, B., Radford, E. P., Fisher, R., and Caplan, Y., A Fire Fatality Study, Fire Journal, Vol. 69, No. 3, 11-14 (May 1975).
5. Hileman, F. D., Voorhees, K. J., Wojcik, L. H., Birky, M. M., Ryan, P. W., and Einhorn, I. N., Pyrolysis of a Flexible Urethane Foam, Journal of Polymer Science: Polymer Chemistry Edition, Vol. 13, 571-584 (1975).
6. Petajan, J. H., Voorhees, K. J., Packham, S. C., Baldwin, R. C., Einhorn, I. N., Grunnet, M. L., Dinger, B. G., and Birky, M. M., Extreme Toxicity from Combustion Products of Fire-Retarded Polyurethane Foam, Science, Vol. 187, 742-744 (Feb. 1975).



Program for Physics and Dynamics

Objectives: to analyze ignition, fire spread, and hot gas circulation...to determine the dominant controlling mechanisms of fire phenomena, and to relate them to fire hazard test results...to characterize smoke aerosols...to relate smoke properties to fire behavior...to determine the dominant factors controlling smoldering combustion.

Program for Physics and Dynamics

John Rockett, Chief

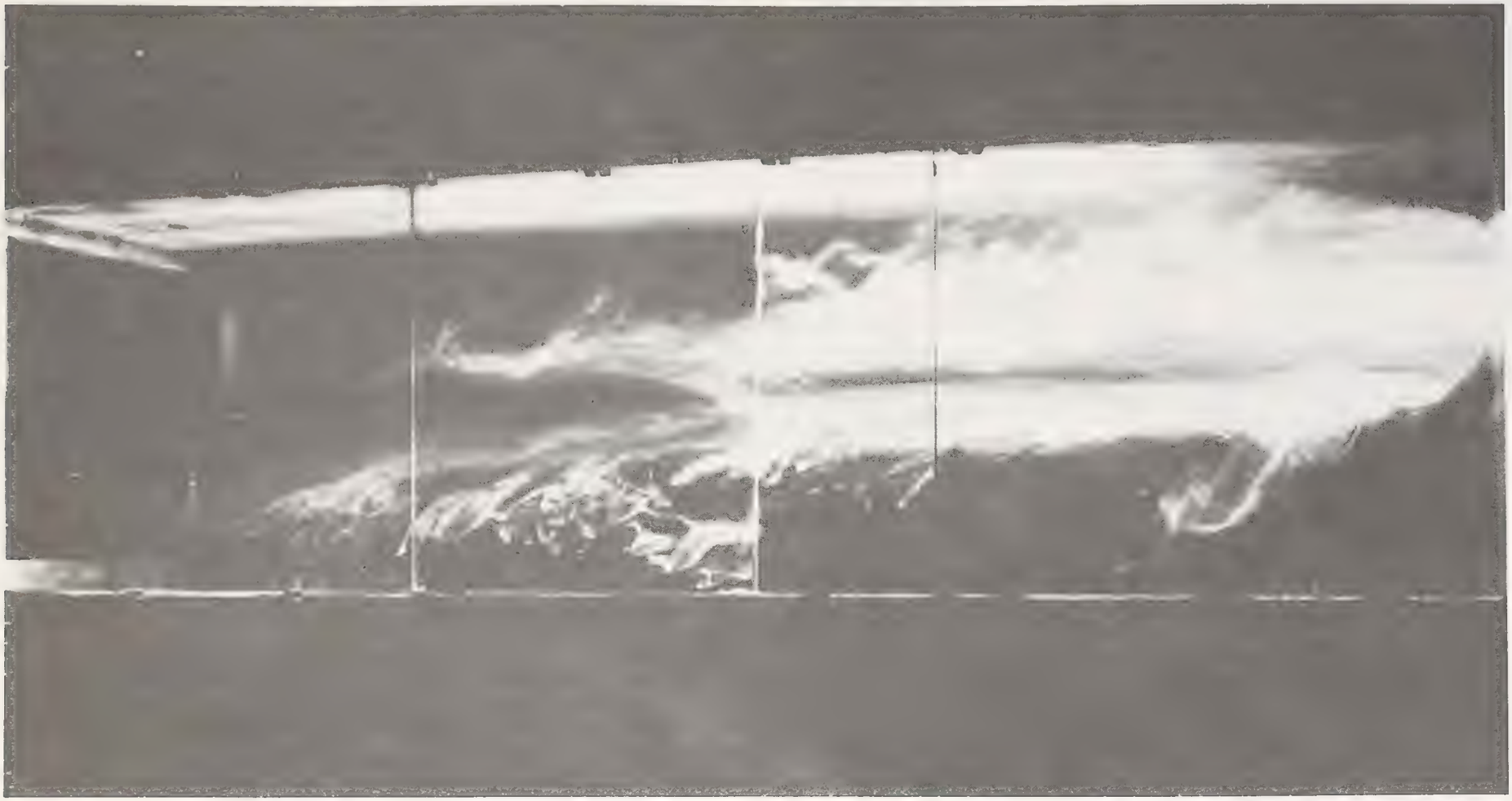
Current Activities:

- Radiative ignition of solids is being studied utilizing a CO_2 laser to simulate fire heat fluxes.
- Mathematical modeling of the ignition process is being carried out.
- Smoldering of cellulosic and polyurethane foam materials is being studied to define the mechanisms of smoldering combustion and to develop methods of inhibiting smolder.
- A laboratory-scale model corridor test facility is being used to investigate the partial scaling relationships in simulating full-scale corridor fire spread.
- Fire induced flows in enclosures and in turbulent flames are being studied, and advanced turbulent flow models are being developed to predict these flows.
- The physical characteristics of smoke are being measured; the mechanisms by which these characteristics change as the smoke ages are being studied.
- A laboratory experiment has been initiated to study the ability of a corridor sprinkler to suppress a fire in an adjacent room.

Physics and Dynamics--Selected Publications:

1. Bromberg, K. and Quintiere, J., Radiative Heat Transfer from Products of Combustion in Building Corridor Fires, National Bureau of Standards (U.S.), NBSIR 74-596 (Feb. 1975), NTIS Order No. COM-75-10209; $3.75.
2. Kashiwagi, T., A Radiative Ignition Model of a Solid Fuel, Combustion Science and Technology, Vol. 8, 225-236 (1974).
3. Kashiwagi, T., A Study of Flame Spread Over a Porous Material Under External Radiation Fluxes, Proceedings of the Fifteenth Symposium (International) on Combustion, The Combustion Institute, Pittsburgh, Pa., 225-265 (1975); held in Tokyo, Japan, 1974.
4. Kashiwagi, T., Flame Spread Over a Porous Surface Under an External Radiation Field. In: Fire Safety Research, Proceedings of a Symposium held at the National Bureau of Standards, Gaithersburg, Md., Aug. 22, 1973. National Bureau of Standards (U.S.), NBS Special Publication 411 (Nov. 1974), GPO; SD Catalog No. C13.10:411; $3.10.
5. Kashiwagi, T., Experimental Observation of Flame Spread Characteristics Over Selected Carpets, Journal of Fire and Flammability/Consumer Product Flammability, Vol. 1, 367-389 (Dec. 1974).
6. McCaffrey, B. J. and Quintiere, J., Fire Induced Corridor Flow in a Scale Model Study, Proceedings of the Conseil International du Batiment (CIB), Symposium on the Control of Smoke Movement in Building Fires held at Building Research Establishment, Garston, England, Oct. 1975.
7. McCarter, R. J., A New Technique for Thermal Analysis of Vapor-Producing Reactions, Journal of Applied Polymer Science, Vol. 17, 1833-1846 (1973).
8. Quintiere, J., Radiative Characteristics of Fire Fighters' Coat Fabrics, Fire Technology, Vol. 10, No. 2, 153-161 (May 1974).
9. Quintiere, J. and Huggett, C., An Evaluation of Flame Spread Test Methods for Floor Covering Materials. In: Fire Safety Research, Proceedings of a Symposium held at the National Bureau of Standards, Gaithersburg, Md., Aug. 22, 1973. National Bureau of Standards (U.S.), NBS Special Publication 411 (Nov. 1974), GPO; SD Catalog No. C13.10:411; $3.10.
10. Quintiere, J., Some Observations on Building Corridor Fires, Proceedings of the Fifteenth Symposium (International) on Combustion, The Combustion Institute, Pittsburgh, Pa., 163-174 (1975); held in Tokyo, Japan, 1974.
11. Quintiere, J., A Characterization and Analysis of NBS Corridor Fire Experiments in Order to Evaluate the Behavior and Performance of Floor Covering Materials, National Bureau of Standards (U.S.), NBSIR 75-691 (June 1975), NTIS Order No. COM-75-11015; $4.75.
12. Quintiere, J., The Application and Interpretation of a Test Method to Determine the Hazard of Floor Covering Fire Spread in Building Corridors, Proceedings of the International Symposium on Fire Safety of Combustible Materials; held in Edinburgh, Scotland, Oct. 1975.

13. Rockett, J. A., Mathematical Modeling of Radiant Panel Test Methods. In: Fire Safety Research, Proceedings of a Symposium held at the National Bureau of Standards, Gaithersburg, Md., Aug. 22, 1973. National Bureau of Standards (U.S.), NBS Special Publication 411 (Nov. 1974), GPO; SD Catalog No. C13.10:411; $3.10.

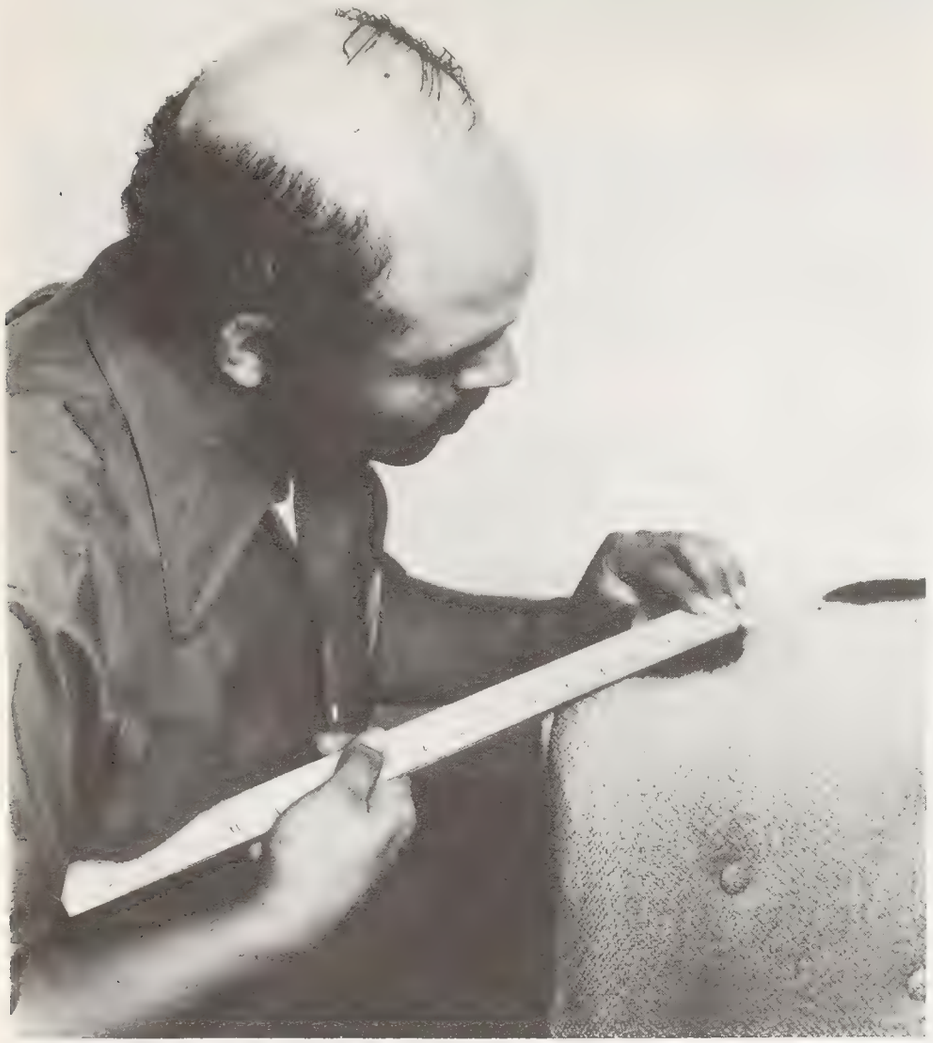




Fire Safety Engineering addresses the solution of real-life fire problems. Progress in these problem areas generally depends on the use of new fundamental knowledge, particularly that generated by the NBS Fire Science Programs. Improved laboratory test methods, procedures, and recommended practices for products and construction assemblies are the results of the Programs for Fire Prevention-Products, Fire Control-Furnishings, Fire Control-Construction, Fire Detection and Control Systems, and Design Concepts.

Attacking the Fire Problem

Center for Fire Research



Program for Fire Prevention

• Products

Objectives: to develop and recommend standards or other regulations to control fire safety aspects of consumer products, particularly in support of the Consumer Product Safety Commission.

Program for Fire Prevention - Products

James Winger, Chief

Current Activities:

- Flammability test methods are being developed and evaluated for use in a standard for upholstered furniture.
- The University of Maryland, under a CFR research grant, is studying ease of extinguishment of apparel fabrics.
- Test method development for the flammability of general apparel is underway.
- The flammability of various consumer products such as Christmas decorations and Easter grass is being studied so that flammability tests can be developed.
- Studies on the effects of laundering, dry cleaning, garment construction, and other variables on garment flammability are proceeding.

Fire Prevention - Products--Selected Publications:

1. Braun, E., Winger, J. H., and Slater, J. A., Development of Standards for the Flammability of Children's Sleepwear. In: Fire Safety Research, Proceedings of a Symposium held at the National Bureau of Standards, Gaithersburg, Md., Aug. 22, 1973. National Bureau of Standards (U.S.), NBS Special Publication 411 (Nov. 1974), GPO; SD Catalog No. C13.10:411; $3.10.

2. Krasny, J. F., Abstracts of Papers on Testing and Analysis of Flammable Fabrics from October 1972 to October 1973, National Bureau of Standards (U.S.), NBSIR 74-455 (Mar. 1974), NTIS Order No. COM-74-10865; $4.50.

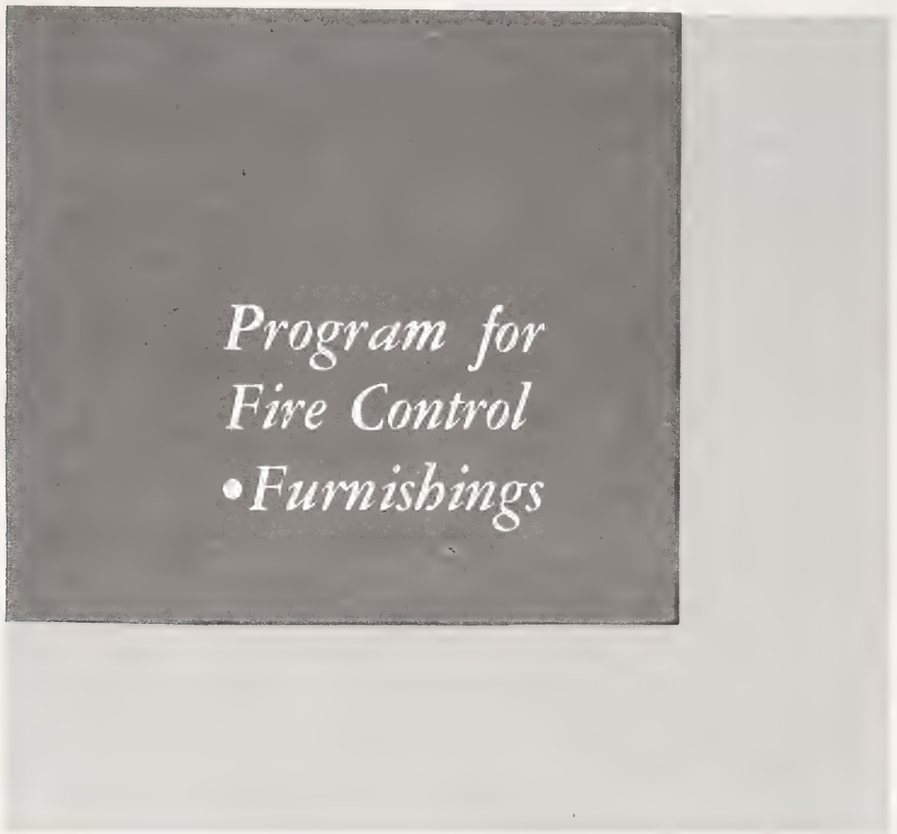
3. Krasny, J. F., Development of Flammability Standards, Proceedings of the Symposium on Textile Flammability, Le Blanc Research Corporation, East Greenwich, R. I., 30-48 (Apr. 1975); held in New York, Apr. 1975.

4. Krasny, J. F. and Francis, J. B., Ranking Extinguishability of Burning Fabrics, Textile Chemist and Colorist, Vol. 6, No. 6, 36-37 (June 1974).

5. Krasny, J. F. and Vaishnav, M., Abstracts of Papers on Testing and Analysis of Flammable Fabrics from October 1973 to October 1974, Proceedings of Eighth Annual Meeting of the Information Council on Fabric Flammability, Galveston, Texas, 72-87 (1975); held in New York, Dec. 5, 1974.

6. Krasny, J. F. and Winger, J. H., Current Status of Flammability Test Development at the National Bureau of Standards, Proceedings of the Eighth Meeting of the Information Council on Fabric Flammability, Galveston, Texas, 151-160 (1975); held in New York, Dec. 5, 1974.

7. Winger, J. H., Recent Advances at the National Bureau of Standards in Development of Flammability and Smoke Tests, Proceedings of the 1975 Polymer Conference Series, Recent Advances in Flame and Smoke Retardance of Polymers, Polymer Institute of the University of Detroit (May 1975).



Objectives: to characterize the fire hazards of interior furnishing and to develop test methods for their control.

Program for Fire Control - Furnishings

Sanford Davis, Chief

Current Activities:

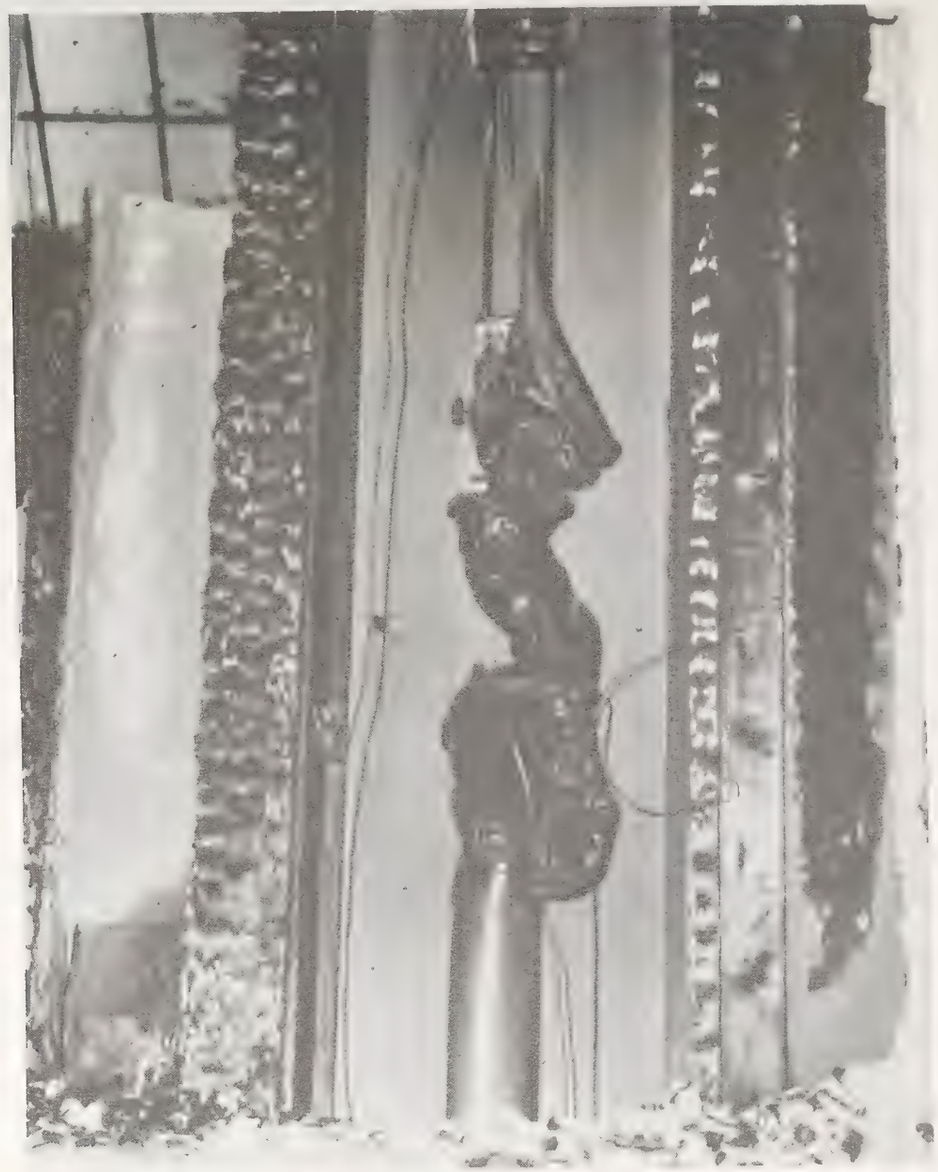
- Full-scale fires of interior furnishings are conducted to study the hazards of individual pieces of furniture. The development of a hazard index is in progress.
- The development of an ease-of-ignition test for thermoplastic materials and for interior furnishing materials, in general, is underway.
- The rate of heat release and total energy from small ignition sources are being determined.
- Correlation of smoke measurements from fires of full-scale furnishings is being made with small-scale chamber tests.
- Test methods are under development for measuring rate of burning and surface flame spread of furnishing materials.



Fire Control - Furnishings--Selected Publications:

1. Braun, E., Report of Fire Test on an AM General Metro Bus, National Bureau of Standards (U.S.), NBSIR 75-718 (June 1975), NTIS Order No. COM-75-10750; $3.25.
2. Lee, T. G. and Huggett, C., Interlaboratory Evaluation of ASTM E-84-70 Tunnel Test Applied to Floor Coverings, Journal of Testing and Evaluation, ASTM, Vol. 3, No. 1, 3-14 (1975).
3. Meisters, M., Concepts and Trends in Polymer Fire Testing, Modern Plastics, Vol. 52, No. 9, 76-82 (Sept. 1975).

Program for • Fire Control Construction



Objectives: to study the flammability characteristics and fire performance of construction materials and assemblies...to develop test methods for various building components...to develop models to predict the course of fire in buildings.

Program for Fire Control - Construction

Daniel Gross, Acting Chief

Current Activities:

- A fire endurance furnace capable of testing structural wall, floor/ceiling, and column assemblies is being completed.
- The effect of the properties of interior finish materials on fire growth in residential and shipboard occupancies is being studied.
- The rate of heat release of wood, plastic, and other construction materials is being studied using calorimetric techniques.
- Mathematical models are being developed to predict fire growth in rooms.
- Fire loads in buildings are being surveyed to update basic data for building codes.
- Reduced scale modeling of room fires is being conducted.
- A versatile flame spread test for multiple configurations (wall, floor, ceiling) is being developed.
- A methodology is being developed for establishing and evaluating new fire test methods dealing with ease of ignition and flame spread.
- Fire growth in mobile homes is being studied.
- Realistic thermal restraint during fire tests of floor and roof assemblies is being studied for CFR by the Portland Cement Association.

Fire Control - Construction--Selected Publications:

1. Fang, J. B., Fire Buildup in a Room and the Role of Interior Finish Materials, National Bureau of Standards (U.S.), Tech. Note 879 (June 1975), GPO; SD Catalog No. C13.46:879; $1.10.
2. Fang, J. B., Measurements of the Behavior of Incidental Fires in a Compartment, National Bureau of Standards (U.S.), NBSIR 75-679 (Mar. 1975), NTIS Order No. COM-75-10419; $3.75.
3. Fang, J. B. and Gross, D., Contribution of Interior Finish Materials to the Growth of Fire in a Room. In: Fire Safety Research, Proceedings of a Symposium held at the National Bureau of Standards, Gaithersburg, Md., Aug. 22, 1973. National Bureau of Standards (U.S.), NBS Special Publication 411 (Nov. 1974), GPO; SD Catalog No. C13.10:411; $3.10.
4. Hartzell, L. G., Development of a Radiant Panel Test for Flooring Materials, Final Report, National Bureau of Standards (U.S.), NBSIR 74-495 (May 1974), NTIS Order No. COM-74-11575; $7.00.
5. Houser, J. L., Development of a Bench Test for Type X Core Gypsum Board, Final Report, National Bureau of Standards (U.S.), NBSIR 74-588 (Dec. 1974), NTIS Order No. COM-75-10040; $3.75.
6. Issen, L. A., An Analytical Model for Calculating the Fire Resistance of Simply Supported Prestressed and Reinforced Concrete Beams. In: Fire Safety Research, Proceedings of a Symposium held at the National Bureau of Standards, Gaithersburg, Md., Aug. 22, 1973. National Bureau of Standards (U.S.), NBS Special Publication 411 (Nov. 1974), GPO; SD Catalog No. C13.10:411; $3.10.
7. Parker, W. J. and Lee, B. T., A Small Scale Enclosure for Characterizing the Fire Buildup Potential of a Room, National Bureau of Standards (U.S.), NBSIR 75-710 (June 1975), NTIS Order No. COM-75-11030; $3.25.
8. Parker, W. J. and Lee, B. T., Fire Buildup in Reduced Size Enclosures. In: Fire Safety Research, Proceedings of a Symposium held at the National Bureau of Standards, Gaithersburg, Md., Aug. 22, 1973. National Bureau of Standards (U.S.), NBS Special Publication 411 (Nov. 1974), GPO; SD Catalog No. C13.10:411; $3.10.
9. Parker, W. J., Paabo, M., Scott, J. T., Gross, D., and Benjamin, I. A., Fire Endurance of Gypsum Board Walls and Chases Containing Plastic and Metallic Drain, Waste and Vent Plumbing Systems, National Bureau of Standards (U.S.), NBS Building Science Series 72 (Sept. 1975), GPO; SD Catalog No. C13.29/2:72; $1.80.
10. Wyly, R. S., Parker, W. J., Rorrer, D. E., Shaver, J. R., Sherlin, G. C., and Tryon, M., Review of Standards and Other Information on Thermoplastic Piping in Residential Plumbing, National Bureau of Standards (U.S.), NBS Building Science Series 68 (May 1975), GPO; SD Catalog No. C13.29/2:68; $1.25.

Program for Fire Detection and Control Systems



Objectives: to develop performance criteria for residential smoke detection devices and systems...to develop design requirements for the use of automatic fire suppression systems for life safety...to develop methods and criteria for the control of smoke movement in buildings.

Program for Fire Detection and Control Systems

Richard Bright, Acting Chief

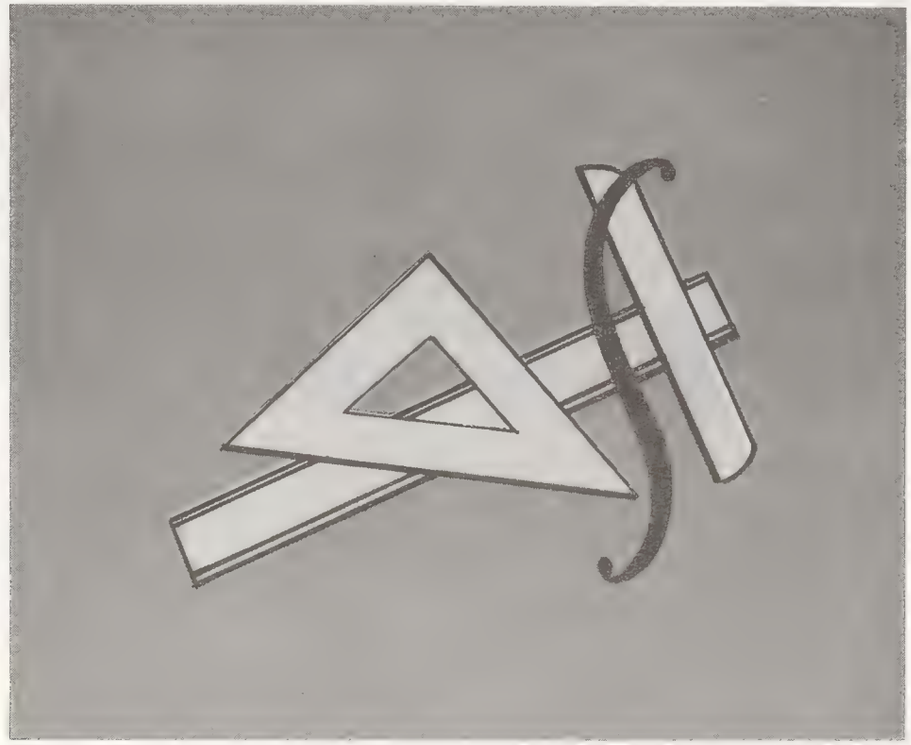
Current Activities:

- Laboratory and field performance tests are being conducted on smoke detectors to outline requirements to be included in future standards.
- Patterns of heat flow in corridors from room fires and water flow rates are being studied to determine the most effective types of sprinklers for various fires.
- A design model is being developed to allow a rational base for corridor sprinkler protection.
- Proposed performance criteria are being prepared for smoke detection devices to assure consistent quality of detectors available to the consumer.
- A computer analysis for modeling smoke movement in buildings is being developed and will be used in conjunction with a gas tracer technique to depict smoke movement.
- Under CFR contract, Integrated Systems is carrying out simulation studies on air movement and smoke diffusion.
- The Illinois Institute of Technology Research Institute is studying detector sensitivity and siting requirements for dwellings, under CFR contract.
- Studies are being conducted on the performance of automatic sprinkler systems and fire detection systems for fires in health care occupancies.

Fire Detection and Control Systems--Selected Publications:

1. Bright, R. G., Recent Advances in Residential Smoke Detection, Fire Journal, Vol. 68, No. 6, 69-77 (Nov. 1974).
2. Bright, R. G., Regulations and Standards Concerning Fire Detection Systems in the U.S., Proceedings of the Seventh International Seminar on Problems of Automatic Fire Detection, March 5-6, 1975, Aachen, Germany.
3. Bukowski, R. W. and Bright, R. G., Taguchi Semiconductor Gas Sensors as Residential Fire/Smoke Detectors, Fire Journal, Vol. 69, No. 3, 30-33 (May 1975).
4. Custer, R. L. P., Detector Actuated Automatic Sprinkler Systems - A Preliminary Evaluation, National Bureau of Standards (U.S.), Tech. Note 836 (July 1974), GPO; SD Catalog No. C13.46:836; $0.65.
5. Custer, R. L. P. and Bright, R. G., Fire Detection: The State-of-the-Art, National Bureau of Standards (U.S.), Tech. Note 839 (June 1974), GPO; SD Catalog No. C13.46:839; $1.55.
6. Fung, F. C. W., Evaluation of a Pressurized Stairwell Smoke Control System for a 12-Story Apartment Building, National Bureau of Standards (U.S.), NBSIR 73-277 (June 1973), NTIS Order No. PB-225278; $3.50.
7. Harrison, G. A., The High-Rise Fire Problem, CRC Critical Reviews in Environment Controls, Vol. 4, No. 4, 483-505 (Oct. 1974).
8. Harrison, G. A. and Houser, J. L., A Survey for the Collection of Professional Opinion on Selected Fire Protection Engineering Topics, National Bureau of Standards (U.S.), Tech. Note 861 (Mar. 1975), GPO; SD Catalog No. C13.46:861; $0.80.

Program for Design Concepts



Objectives: to synthesize and integrate research results into total design concepts for fire safety in buildings and other structures.

Program for Design Concepts

Harold Nelson, Chief

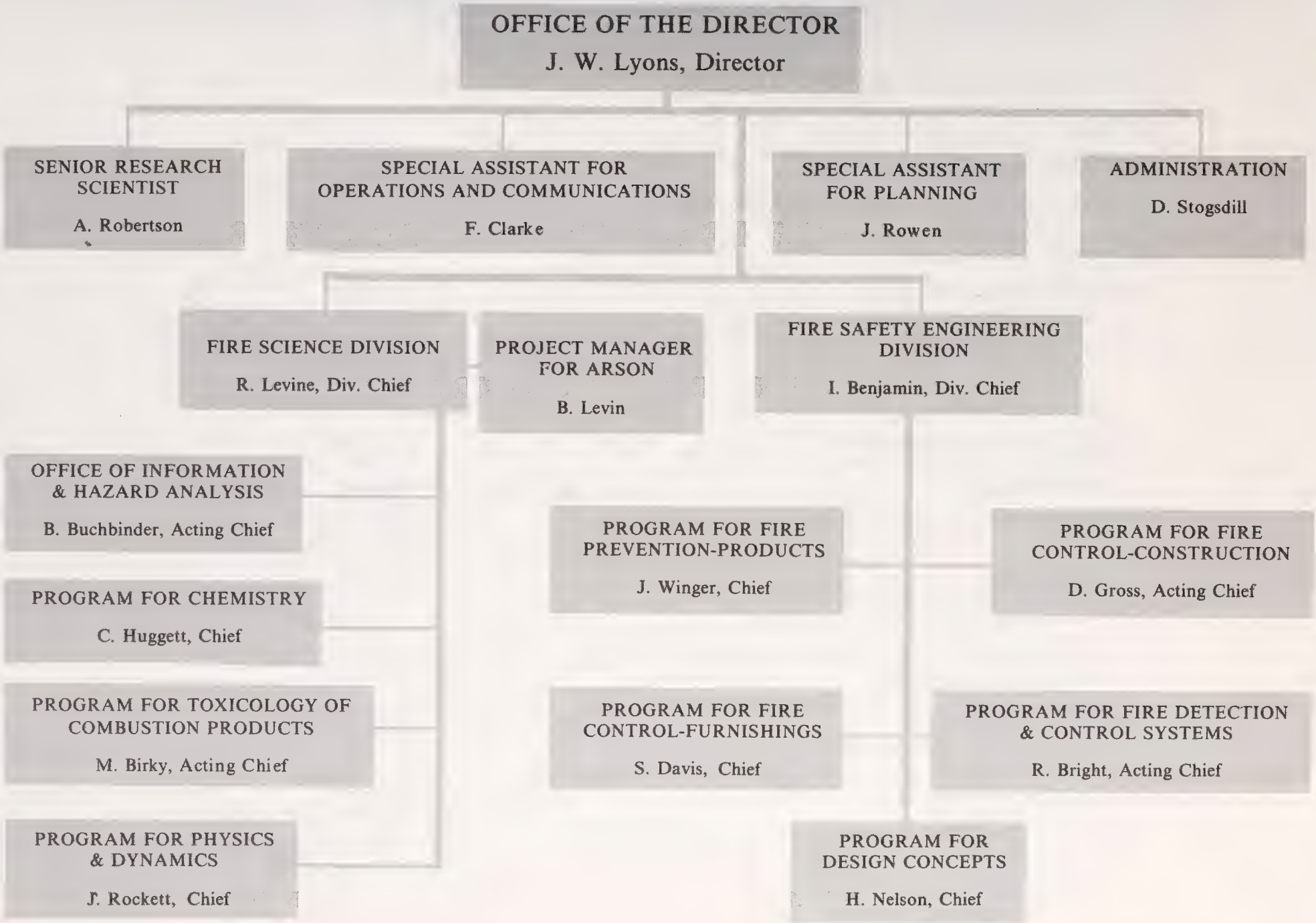
Current Activities:

- Studies, research, and tests are being conducted to develop a scientific base of knowledge of fire safety for rational approaches to life safety in institutions and other occupancies.
- A decision analysis study is underway to qualify and quantify hazard-producting and hazard-controlling elements to establish a logic mechanism to achieve optimun safety effectiveness, cost effectiveness, and design flexibility.
- Tests, analyses, and studies are being conducted to improve the ability to predict probable growth rates and ultimate severities of fires in rooms and the impact of these on various types of materials, furnishings, finishes, and arrangements.
- Studies are underway to find recurrent patterns of behavior for individuals and groups which can be used in the development of regulations or which can provide guidance in building design.
- Studies are being undertaken involving human factor laboratory investigations and other studies to determine means and methods of emergency alarm and communication devices, systems, and methodologies.
- Tests and evaluations are included to determine the most practical, reliable, and effective means to control smoke movement in both small and large structures.
- Tests and studies are being conducted to cover all aspects of design, usage, capabilities, and cost optimization of automatic sprinkler installations in low hazard occupancies such as hospital rooms, school rooms, or offices.



The technical output of the Center for Fire Research must enter the general community to be effective. Standards are the principal mechanism for moving from the laboratory to the public. Thus, cooperation between technical staff and standards-making organizations is essential to insure the wide application of our research. A list of technical committee appointments is given in Appendix B.

APPENDIX A


OFFICE OF THE DIRECTOR
J. W. Lyons, Director
SENIOR RESEARCH SCIENTIST
A. Robertson
SPECIAL ASSISTANT FOR OPERATIONS AND COMMUNICATIONS
F. Clarke
SPECIAL ASSISTANT FOR PLANNING
J. Rowen
ADMINISTRATION
D. Stogsdill
FIRE SCIENCE DIVISION
R. Levine, Div. Chief
PROJECT MANAGER FOR ARSON
B. Levin
FIRE SAFETY ENGINEERING DIVISION
I. Benjamin, Div. Chief
OFFICE OF INFORMATION & HAZARD ANALYSIS
B. Buchbinder, Acting Chief
PROGRAM FOR CHEMISTRY
C. Huggett, Chief
PROGRAM FOR TOXICOLOGY OF COMBUSTION PRODUCTS
M. Birky, Acting Chief
PROGRAM FOR PHYSICS & DYNAMICS
J. Rockett, Chief
PROGRAM FOR FIRE PREVENTION-PRODUCTS
J. Winger, Chief
PROGRAM FOR FIRE CONTROL-CONSTRUCTION
D. Gross, Acting Chief
PROGRAM FOR FIRE CONTROL-FURNISHINGS
S. Davis, Chief
PROGRAM FOR FIRE DETECTION & CONTROL SYSTEMS
R. Bright, Acting Chief
PROGRAM FOR DESIGN CONCEPTS
H. Nelson, Chief

APPENDIX B

Staff Participation in Voluntary Standards Organizations

American Society for Testing and Materials (ASTM)

D-13 Textiles	J. Winger
SC D13.52 Textile Flammability	J. Winger
SC D13.52.01 Ad Hoc on Heat Transfer Measurements	J. Krasny
D-20 Plastics	L. Breden
SC D20.30 Thermal Properties	L. Breden
E-5 Fire Tests of Materials and Construction	I. Benjamin, Vice Chairman A. Robertson D. Gross - Alt. L. Issen - Alt.
SC E5.01 Construction Assemblies	I. Benjamin
TG Restraint Floors and Beams	A. Robertson
TG Alternatives	D. Gross
SC E5.02 Smoke and Combustion Products	A. Robertson D. Gross
TG Smoke Measurements	D. Gross
TG Heat Release Rate Methods	W. Parker A. Robertson
SC E5.03 Protection of Openings	
TG Furnace Standardization	D. Gross
SC E5.04 Surface Burning	A. Robertson D. Gross - Alt.
TG Flammability of Floor Coverings	A. Robertson
SC E5.05 Terminology	D. Gross
TG Noncombustibility	D. Gross
SC E5.10 Research	A. Robertson I. Benjamin

SC E5.91 Editorial	D. Gross
SC E5.92 TAG ISO/TC 92 International Standards	D. Gross A. Robertson I. Benjamin
E-39 Fire Hazard Standards	J. Lyons I. Benjamin - Alt.
SC E39.04 Recommended Practices	I. Benjamin
SC E39.10 Division of Planning and Research	J. Lyons
TG Integration of Research Data	D. Gross
TG Compartment Fire Hazards	I. Benjamin W. Parker
SC E39.2003 Building Furnishings or Contents	S. Davis
SC E39.2005 Wearing Apparel	J. Krasny
SC E39.2008 Transportation Facilities	S. Davis
F-7 Aerospace Industry Methods	D. Gross
SC F7.06 Flammability	D. Gross
G-4 Behavior of Materials in O_2 Distribution Systems	C. Huggett

National Fire Protection Association (NFPA)

Safety to Life	I. Benjamin
Sec. Committee on Means of Egress	I. Benjamin
Sec. Committee on Residential Occupancies	I. Benjamin H. Shoub
Sec. Committee on Health Care Facilities	R. Bright H. Nelson
Sec. Committee on Extinguishing Systems	R. Custer
Exposure Fire Protection	A. Robertson
Static Electricity	A. Robertson
Fire Tests	A. Robertson I. Benjamin

Sec. Committee on Furnishings	C. Huggett S. Davis
Automatic Sprinklers	R. Custer
Sec. Committee on Fuel Loading	R. Custer
Sec. Committee Water Supply	R. Custer
Sec. Committee on Spacing, Location, Position	R. Custer
Dwelling Fire Prevention and Protection	R. Bright
TAG, ISO/TC 21 Fire Fighting and Protection Equipment	R. Bright
Household Fire Warning Equipment	R. Bright
Fire Incident Reporting	B. Buchbinder
Air Conditioning and Ventilation	I. Benjamin F. Fung
Combustion Measurements	
Informal Gov't. Working Group	R. Levine
Conseil International Du Batiment (CIB)	
CIB Commission W.14 Fire	D. Gross A. Robertson
Coordinating Research Council	
Aviation Fuel Safety Panel	A. Robertson
Federal Construction Council/Building Research Advisory Board (FCC/BRAB)	
Fire Protection and Safety Engineering	H. Shoub D. Gross
Federal Fire Standards	H. Nelson
Fiber Society	J. Krasny
General Services Administration (GSA)	
Protection of Archives and Records	H. Nelson

Information Council on Fabric Flammability (ICFF)

Research and Testing	J. Krasny

International Comm. Design & Planning Tall Bldgs.

Fire and Blast 8	H. Nelson

International Conference of Building Officials (ICBO)

Fire and Life Safety	I. Benjamin

Intergovernmental Maritime Consultative Organization (IMCO)

Fire Protection/Fire Tests	A. Robertson

International Standards Organization (ISO)

ISO/TC 92 Fire Tests on Building Materials and Structures

WG 2 Noncombustibility & Heat Release	I. Benjamin
WG 3 Door Assemblies	D. Gross
WG 4 Reaction to Fire	A. Robertson
WG 7 Coordination & Planning	
WG 10 Measuring Instruments	
WG 11 Fire Resistance Tests	

ISO/TC 21 Equipment for Fire Protection & Fire Fighting

WG 1 Automatic Sprinklers	R. Custer

ISO/TC 38/SC 19 Burning Behavior of Textiles

WG 2 Apparel	J. Winger
WG 3 Furnishings	J. Winger
WG 5 Floor, Wall, & Ceiling Coverings	J. Winger
WG 6 Risk Data Analysis	J. Winger

Model Code Conferences and Organizations

Model Code Standardization Council	I. Benjamin

Products Research Committee (PRC) J. Lyons

Underwriters' Laboratories (UL)

Fire Council	H. Nelson
Ad Hoc Standards Development	R. Custer
Records Protection	H. Nelson
Building Construction	H. Nelson
Systems Concepts Fire Protection in Structures	H. Nelson
Rapid Rail Transit	S. Davis
Fire Hazards in O_2 Enriched Atmospheres	C. Huggett

Society of Fire Protection Engineers (SFPE)

Executive	H. Nelson
Measurement of Fire Phenomena	H. Nelson
Research	J. Rockett

American Association of Textile Chemists and Colorists (AATCC)

RA 82 Flammability and Fire Resistance	J. Krasny

American Concrete Institute (ACI)

Fire Resistance and Fire Protection Structures 216	L. Issen

American Society of Civil Engineers (ASCE)

Task Group on Fire Protection	I. Benjamin
Fire Safety Standards	I. Benjamin

American Society for Heating, Refrigeration, Airconditioning Engineers (ASHRAE)

TC 5.6 Fire and Smoke Safety	F. Fung

U.S. Coast Guard

Safety of Life at Sea/Fire Protection	A. Robertson

APPENDIX C

Measures of Success - Accomplishments in FY 1975

Information and Hazard Analysis:

- A hazard analysis project was initiated to survey the fire hazards of plastics.
- The pilot implementation of the National Fire Data System was completed and transferred to the National Fire Prevention and Control Administration.
- Studies were completed on the effect of human activity and garment characteristics on the severity of injuries from apparel fires.
- Full-scale fire tests on draperies were performed as a part of a hazard characterization process.

Chemistry:

- A relationship between flammability limits in pre-mixed flames and diffusion flames was established.
- The oxygen index of liquids was studied as a function of temperature, providing new insight into the significance of the oxygen index as a measure of fire behavior.
- A prototype system for measuring the flash fire potential of aircraft interior materials was constructed.
- A computer model of a laminar diffusion flame was developed and used to study flame inhibition processes.
- A new phosphorus-containing species thought to be important in gas phase flame inhibition was identified.

Physics and Dynamics:

- A study of flame spread over thin inclined cellulosic sheets was completed.
- Preliminary results from studies of smoldering polyurethane foams indicate a high degree of correlation between smoldering and charring tendencies.
- Methodology was developed for applying test method results to determine the potential flame spread of floor coverings in building corridors.
- Recirculating fire induced flows were measured in both small-scale and full-scale corridors.
- The capability for measuring the particle size distribution and mass concentration of smoke was developed.
- A laboratory automation program was begun with the selection of a minicomputer system and the establishment of a computer operations staff within the Center.

Fire Prevention - Products:

- Standard for the Flammability of Children's Sleepwear, Sizes 7-14, went into effect May 1, 1975.
- A proposed standard for the flammability of upholstered furniture was drafted and recommended to the Consumer Product Safety Commission.
- A study of the effects of dry cleaning on the flammability of apparel fabrics was completed, and a tentative dry cleaning test procedure was developed.
- The durability of flame retardant cotton batting which is used in mattresses was studied.
- A project to study the flammability of flight attendant uniforms for the Federal Aviation Administration was completed.
- An improved test method for the flammability of powders, pastes, and granules was developed.
- A new test concept for measuring the flammability of apparel was developed.

Fire Control - Furnishings:

- A flooring radiant panel test was developed for measuring the flame spread of flooring systems used in corridors and exitways of regulated occupancies. The test is now being adopted by government agencies and industry.
- The fire safety of interior components of AM general buses and METRO subway cars was evaluated for the Washington Metropolitan Area Transit Authority.
- A burn room facility for evaluating the hazards of interior furnishings involved in fire was designed and instrumented. A study of parsons tables was completed in this facility.

Fire Control - Furnishings:

- A technique for measuring the smoke generation of thermoplastic materials in the NBS Smoke Density Chamber was developed.

Fire Control - Construction:

- A comprehensive summary of fire endurance tests on walls containing plastic pipe for drain, waste, and vent plumbing systems was published.
- A report on the contribution of interior finish materials to fire buildup in a room was completed.
- Reduced scale and analytical modeling techniques for predicting fire growth in rooms were developed and tested.
- The Potential Heat Test Method was adopted, by reference, in the National Building Code and National Fire Protection Association Standard 220.
- The heat release rates of fire retardant treated wood products and foam plastics were investigated using the NBS heat release rate calorimeter.

Fire Detection and Control Systems:

- The suggested performance standards for single-station smoke detectors were adopted and published as a proposed standard by Underwriters' Laboratories, Inc.
- Studies of automatic sprinkler discharge patterns for corridor sprinkler systems were completed.
- Smoke movement and control were studied in five VA hospitals.
- Smoke control measures in two Federal high-rise office buildings were verified.

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16. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

The mission of the Center for Fire Research is to insure the development of the technical base for the standards and specifications needed in support of the National goal to reduce fire losses by 50% over the next generation. A systems approach to accomplish this mission is described. The Center consists of four basic programs in the area of Fire Science and five applied research programs in the area of Fire Safety Engineering. Each applied program addresses an aspect of the Fire Problem, using fundamental information supplied by the basic research function. Active participation by staff members in voluntary standards organizations is the principal means of making this technology available for codes and standards needed to reduce the Nation's fire loss.

17. KEY WORDS *(six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons)*

Building design; consumer protection; fire control; fire detection; fire research; fire spread; flammability.

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Monographs—Major contributions to the technical literature on various subjects related to the Bureau's scientific and technical activities.

Handbooks—Recommended codes of engineering and industrial practice (including safety codes) developed in cooperation with interested industries, professional organizations, and regulatory bodies.

Special Publications—Include proceedings of conferences sponsored by NBS, NBS annual reports, and other special publications appropriate to this grouping such as wall charts, pocket cards, and bibliographies.

Applied Mathematics Series—Mathematical tables, manuals, and studies of special interest to physicists, engineers, chemists, biologists, mathematicians, computer programmers, and others engaged in scientific and technical work.

National Standard Reference Data Series—Provides quantitative data on the physical and chemical properties of materials, compiled from the world's literature and critically evaluated. Developed under a world-wide program coordinated by NBS. Program under authority of National Standard Data Act (Public Law 90-396).

NOTE: At present the principal publication outlet for these data is the Journal of Physical and Chemical Reference Data (JPCRD) published quarterly for NBS by the American Chemical Society (ACS) and the American Institute of Physics (AIP). Subscriptions, reprints, and supplements available from ACS, 1155 Sixteenth St. N. W., Wash. D. C. 20056.

Building Science Series—Disseminates technical information developed at the Bureau on building materials, components, systems, and whole structures. The series presents research results, test methods, and performance criteria related to the structural and environmental functions and the durability and safety characteristics of building elements and systems.

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